Transformers

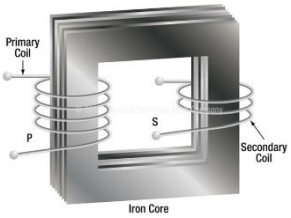
Function of a transformer: A transformer changes electrical energy of a given voltage into electrical energy at a different voltage level.

transformer consists of three basic parts:

1, iron core, provides a circuit of low reluctance for magnetic lines of force

2, primary winding, receives the electrical energy from the source of applied voltage

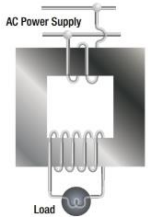
3, secondary winding, receives electrical energy by induction from the primary coil.



two classes of transformers:

1, voltage transformers, used for stepping up or stepping down voltages

(the primary coils are connected in parallel across the supply voltage)



2, current transformers, used in instrument circuits

(the primary windings of current transformers are connected in series in the primary circuit)

step-up or step-down transformers

turns ratio determines whether a transformer is a step-up, or step-down.

The turn ratio is the ratio of the number of turns in the primary winding to the number of turns in the secondary winding

primary coil > secondary coil => Step Down The current output is high and the voltage is high

primary coil < secondary coil => Step UP THE CURRENT OUTPUT IS LESS AND THE VOLTEG IS less

Efficiency of transformers

- **All the magnetic lines of force set up in the primary do not cut across the turns of the secondary coil.**
- **Amount of the magnetic flux, called leakage flux, leaks out of the magnetic circuit.**

The measure of how well the flux of the primary is coupled into the secondary is called the "coefficient of coupling".

$$\text{coefficient of coupling} = \frac{\text{SFlux}}{\text{PFlux}}$$

Power in transformers

The power (I × V) of the output (secondary) electrical energy is the same as the input (primary) power minus that energy loss in the transforming process.

$$\frac{VP}{VS} = \frac{NP}{NS} \qquad V_2 = V_1 \, x \, \frac{N_2}{N_1} \qquad \frac{\text{NP}}{\text{NS}} = \frac{\text{IP}}{\text{IS}} \qquad I_2 = I_1 \, x \, \frac{N_1}{N_2}$$

$$\frac{vp}{vs} = \frac{IS}{IP}$$

Power transformers are used to step up or step down voltages and current in many types of power supplies

1, The secondary is made up of three separate windings

2, Each winding supplies a different circuit with a specific voltage, which saves the weight, space, and expense of three separate transformers

3, Each secondary has a midpoint connection, called a "center tap," which provides a selection of half the voltage across the whole winding.

Audio transformers resemble power transformers

They have only one secondary and are designed to operate over the range of audio frequencies (20 to 20 000 cps).

RF transformers are designed to operate in equipment that functions in the radio range of frequencies.

The symbol for the RF transformer is the same as for an RF choke coil. It has an air core.

Autotransformers are normally used in power circuits; however, they may be designed for other uses.

- Two different symbols for autotransformers used in power or audio circuits.

Current Transformers

used in AC power supply systems to sense generator line current and to provide a current, proportional to the line current, for circuit protection and control devices.

ring-type transformer

a ring-type transformer using a current carrying power lead as a primary.

The current in the primary induces a current in the secondary by magnetic induction.

TRANSFORMER LOSSES AND METHODS TO OVERCOME THEM

Transformer losses are solely electrical losses (as there are no moving parts in a transformer). They consist of copper and core (iron) losses

1, CORE LOSSES

#Core losses are divided into Hysteresis losses and Eddy current losses

A, Eddy Currents result from magnetic flux inducing EMF in other parts such as steel or iron core.

.A1, Small circulating eddy currents result in energy dissipating as heat

A2, large power transformers this loss factor can be critical in terms of heat build up resulting sometimes in fire hazards.

A3, the core is made up of thin sheet laminations with each sheet separated by lacquer or oxide materials which assist in reducing these currents.

In the construction of high frequency transformers, eddy current losses are reduced by using a core made of a ceramic material containing a large proportion of tiny metal particles; iron dust or manganese zinc. The ceramic insulates the metal particles from each other, giving a similar .effect to laminations; performance is better at high frequencies

B, Hysteresis losses result from the electrical energy required to reverse magnetization of the core during each cycle.

B1, Ideal core material having low reluctance, such as iron and high-density cores help to .reduce these losses

B2, stray magnetic Flux (that does not link the primary and secondary windings) also contributes to hysteresis losses.

2, COPPER LOSSES

1, Copper losses (so termed as most transformer windings are manufactured from copper)

1.1 are caused by the ohmic resistance of the primary and secondary windings.

1.2 these losses are directly dependent on the transformer load.

1.3 Increasing transformer load increases current flow and thus results in increase of losses.

Copper losses become very important at high power levels; they're reduced by methods such as: increasing operating voltages or shunt compensation or balancing loads.

Typical losses in power transformers are 3 percent; meaning that transformer efficiency is .approximately 97 percent

TRANSFORMER ACTION

- Transformer action varies under load and no-load conditions.
- In ideal conditions of zero losses, the power in both primary and secondary windings will be the same.
- With no load, secondary current will be zero, and so secondary power will be zero.
- With a voltage applied to the primary, no current will flow as the primary power will also be zero.
- In practice though, with the inherent small losses, there will be a very small primary current to produce the magnetic flux and by the inherent losses.
- Core losses vary little under load and no-load conditions.

Transformer polarity

Transformer Polarity refers to the relative direction of the induced voltages between the high and low voltage terminals.

Three phase voltage

1, supplies are utilized where large power applications are required.

2, More efficient machines can be designed that require three phase AC power.